ECONOMIC EVALUATION OF CALIFORNIA'S PREVENTION CASE MANAGEMENT INTERVENTION FOR HIV-POSITIVE AND HIV-NEGATIVE PERSONS: THE HIV TRANSMISSION PREVENTION PROJECT (HTPP)

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Background

The HIV Transmission Prevention Project (HTPP) was a prevention case management intervention developed to reduce risk behaviors among HIV-negative and HIV-positive individuals. Program staff at 11 sites in California implemented HTPP. The intervention included one-on-one sessions with clients which provided the context for developing individualized risk reduction plans built around incremental steps towards long-term behavior change. In addition, the sessions provided an opportunity to identify and address clients' basic needs, such as housing or medical care. The evaluation of HTPP included the completion by clients of baseline and follow-up questionnaires. The objective of this study was to perform a cost-effective analysis for each of the core four years the intervention was in operation and to assess trends among program outcomes (HIV infections averted), program costs, and program cost-effective metrics.

Method

Annual estimates of averted HIV infections were calculated using standard Bernoulli probability models. Self-reported behavioral data from 194 clients, who completed a baseline and follow-up questionnaire, were used as inputs into the model. Intervention costs were provided by the California Department of Health Services, Office of AIDS. Estimates of annual program costs were derived using average cost per client per year. Annual program cost estimates were compared to the expected future medical care costs associated with estimated HIV infections. To allow for comparability, all cost data were adjusted to June 2003 dollars. Cost-effective metrics were derived using standard economic evaluation methods.

Results

In general, the project showed an upward trend over time for total number of HIV infections averted. In the final fiscal two years of the project (2002-2003 and 2003-2004), 7 and 11 HIV infections were estimated to be averted, respectively. The project was cost-effective three of four years, and was cost-saving in two of the four years.

Discussion

HTPP was capable of holding program costs relatively constant while increasing program effectiveness (i.e., having a greater impact on client behavior), in effect making the project more cost-effective over time. Overall, the stability of results across modeled scenarios and successful program and economic outcomes suggest the substantial investment in prevention resources was an effective and sound policy.

INTRODUCTION

Efficacy is often the sole criterion used for selecting an HIV prevention intervention. However, it is wise to consider program costs in relation to program effectiveness, as determined through economic and probability models, when various interventions are under consideration. The purpose of this study was to utilize retrospective program cost data along with client self-reported data to review trends among program costs; outcome metrics, including HIV infection averted; and the combination, thereof, to assess the cost-effectiveness of a four-year prevention case management intervention, the HIV Transmission Prevention Project (HTPP).

The Intervention

The California Department of Health Services, Office of AIDS (CDHS/OA), HTPP was a risk reduction intervention implemented at 11 sites in California and consisted of one-on-one sessions between clients and program staff. Program staff were master's level mental health counselors who received ongoing training and participated in case conferencing with professionals with expertise in areas of relevance to the issues facing HTPP clients (e.g., substance abuse or sexual abuse) at quarterly meetings organized and facilitated by CDHS/OA. The Harm Reduction Model served as the foundation for behavior change. This model focuses on reducing risk in incremental and measurable steps and recognizes that significant behavior change is a long-term process.

Given the number of interrelated factors that indirectly or directly facilitated clients' risk behaviors (e.g., distrust of service providers, unemployment, chaotic relationships, or mental disorders), initial sessions consisted of building trust with clients. Program staff also addressed clients' basic or immediate needs, such as housing, food, or treatment of acute medical conditions. HTPP was designed to intervene with factors that directly influenced risk behavior, and was not meant to function as a general case management program. However, helping clients meet basic needs built trust and stabilized life circumstances, thereby creating an environment in which clients were better able to consider changes in risk behavior.

Counseling allowed for the recognition of clients' ability to participate in various types of risk reduction activities. Clients and program staff together developed goals that represented specific behaviors or cognitive shifts that the client agreed to attempt to reduce risk directly or to reduce the impact of factors influencing risk. Subsequent sessions included the review and adjustment of the goals. Adjustments included moving on to new and more challenging goals, revisiting and revising goals, and even "backtracking" to re-define goals that were determined to be overly ambitious given the client's current circumstances.

The evaluation of HTPP included obtaining self-reported risk behavioral data via self-administered questionnaires shortly after enrollment into the program, and then up to 6-, 12-, and 18-months post-baseline. Clients were recruited to complete the behavioral questionnaires by program staff. Nearly 90 percent of questionnaires were completed by self-administration and mailed directly to the program evaluators. Baseline and follow-up behavioral data were recorded by means other than self-administration when clients demonstrated reading difficulties or could only be reached by phone.

METHODS

The cost-effective analyses of HTPP were conducted for four fiscal years (2000-2001 through 2003-2004) and utilized program and published medical care cost data. Various model inputs were required to project the number of HIV infections averted, including behavioral data from HTPP clients and published estimates of per-act probabilities for HIV transmission and condom failure rates. These data were then used to calculate cost-effective ratios (program cost over HIV infections averted) for each fiscal year to determine whether HTPP was cost effective. These data were also compared to the cost of treating persons living with HIV, to determine if HTPP turned out to be a cost-saving intervention.

Program Cost

HTPP cost data were collected retrospectively (data reflect actual expenditures) as reimbursement to program sites by CDHS/OA. Individual program sites expenditures were summed to arrive at total program cost per fiscal year, and were adjusted (to account for inflation) to be expressed in 2003 dollars for cost comparability. To perform this adjustment, we used the consumer price index (CPI) which is the best overall estimate of the rate of inflation in the United States [1]. The adjusted value is equal to the product of program costs (for each fiscal year) and the average CPI value (for that fiscal year) over the average CPI value for fiscal year 2003.

Table 1 displays the average CPI values for each fiscal year of HTPP intervention. The average CPI was calculated as the sum of all CPI values (between July and June of the corresponding fiscal year) over 13. The multiplier, for each fiscal year, is equal to the CPI value for fiscal year 2003 over the average CPI. The product of the multiplier and the total program cost is equal to the inflation adjusted program cost. All program costs are reported as inflation adjusted.

Table 1. Average CPI and Multiplier by Fiscal Year

Fiscal Year	CPI	Multiplier
2000-2001	174.87	1.063
2001-2002	178.11	1.044
2002-2003	181.94	1.022
2003-2004	185.93	1.000

Source: U.S. Bureau of Labor Statistics.

Program cost per clients was calculated as total program cost over all clients, per fiscal year, and was used to derive the estimated program cost for those clients included in the cost-effective analysis. The estimated program cost was equal to the product of the program cost per clients and the number of clients included in the cost-effective analysis for the corresponding fiscal year. The number of clients overall, per fiscal year, was the sum of clients having a baseline or follow-up questionnaire during that fiscal year. The number of clients per fiscal year included in the cost-effectiveness analysis had to have all model inputs – demographic and behavioral data, reported HIV serostatus, and a follow-up questionnaire. Given these criteria, some clients are counted more than once over fiscal years.

Estimated Medical Care Cost

Estimates of the discounted, present value of the medical care costs, and treatment for each HIV infection prevented, were performed. Holtgrave [2] offers three scenarios of estimated cost, each to model actual levels of HIV care and treatment consumed by HIV-positive clients and their associated quality of life at each stage of HIV disease. The three scenarios are the low-, intermediate-, and high-cost scenario. (Table 2).

Table 2. Lifetime Medical HIV/AIDS Costs

	Cost of Illness Averted (Quality-Adjusted Life Years Saved)		
	Discount Rate		
Scenario	0%	3%	5%
Low-cost	118,892.00	87,045.00	71,143.00
	(26.85)	(13.18)	(8.57)
	77,351.00	56,595.00	46,236.00
	(26.85)	(13.18)	(8.57)
Intermediate-cost	274,766.00	195,188.00	157,348.00
	(23.87)	(11.23)	(7.10)
	216,544.00	154,402.00	124,728.00
	(23.87)	(11.23)	(7.10)
High-cost	424,763.00	296,844.00	239,945.00
	(20.37)	(9.34)	(5.87)
	351,053.00	248,224.00	202,073.00
	(20.37)	(9.34)	(5.87)

Source: Holtgrave [2].

Given these estimates are in 1996 U.S. dollars, we used the CPI Medical Care Expenditure Category to obtain index values to adjust these costs to 2003 dollar values [3]. We adjusted medical care costs by taking the product of each medical care cost for each scenario and the value of the average 1996 index value over the average 2003 index value. In 2003, the average value of CPI for the Medical Care Expenditure Category was 303.53 and in 1996 the value of the index was 231.57 [3]. The value of the former over the latter value yielded a multiplier of 1.31. The multiplier value best represents the percent increase of medical care expenditures during that time period; as such, this value was used as a multiplier to adjust estimates of the lifetime medical treatment care costs associated with HIV/AIDS from Table 3. The adjusted intermediate base case result, discounted at a three percent rate, is equal to $255,848.85 (Table 3), and is similar to other published estimates.

Table 3. Inflation Adjusted Estimates of Lifetime HIV/AIDS Medical Costs

Adjusted Estimates	Cost of Illness Averted (Quality-Adjusted Life Years Saved)		
	0%	3%	5%
Low-cost	155,841.45	114,096.99	93,252.94
	(26.85)	(13.18)	(8.57)
	101,390.27	74,183.69	60,605.30
	(26.85)	(13.18)	(8.57)
Intermediate-cost	360,158.23	255,848.85	206,248.87
	(23.87)	(11.23)	(7.10)
	283,841.90	202,387.31	163,491.17
	(23.87)	(11.23)	(7.10)
High-cost	556,771.54	389,097.66	314,515.50
	(20.37)	(9.34)	(5.87)
	460,153.82	325,367.46	264,873.58
	(20.37)	(9.34)	(5.87)

Source: CDHS/OA.

Estimating HIV Infections Averted

The Bernoulli-process model of HIV transmission is the preferred model to estimate the likelihood of a person becoming infected with or transmitting HIV [2]. This probability model assumes that each act of intercourse is an independent event that has a small, fixed probability of HIV transmission from an infected person to an uninfected person. The event is defined as infectivity, the per-act probability of transmitting HIV.

Separate calculations are used to estimate the probability of infection among HIV-negative persons (primary infections) and probability of transmission from HIV-positive persons (secondary infections). The formula for estimating primary infections is [2]:

$$P(s) = 1 – \{(1 – \pi) + \pi(1 – \alpha_1)^{n1} (1 – (1- \acute{\varepsilon})\alpha_1)^{k1} (1- \alpha_2)^{n2} (1-(1- \acute{\varepsilon}) \alpha_2)^{k2}\}^m$$

The formula accounts for separate type of acts (n/k) where protected acts are denoted as k. In addition, m represents total number of partners (an increased number has a compounded effect on probability of transmission); π represents the prevalence of infection among partners, and α represents the per-act transmission probabilities of unprotected acts. Finally, έ accounts for condom failure rate.

The formula for estimating the number of secondary infections expected to occur is [2]:

$$S(s) = m(1 – \pi)\{1 - (1 – \alpha_1)^{n1} (1 – (1- \acute{\varepsilon})\alpha_1)^{k1} (1- \alpha_2)^{n2} (1-(1- \acute{\varepsilon}) \alpha_2)^{k2}\}$$

Inputs into the Bernoulli-process model for our analyses included number of sexual partners and the proportion of protected/unprotected acts of intercourse reported on the HTPP questionnaire. Frequency of condom use was assessed on a five-point scale (1 = Always and 5 = Never). Responses were converted to a proportion of protected versus unprotected acts, where a response of 'Always' was converted to a value of 1.0 and a response of 'Never' to 0.0. Estimates of the average frequency of sexual contacts within a two-month period (the time frame from which clients were asked to report their behaviors) were estimated from Cohen, Farley, and Wu [4].

In Table 4 are parameters utilized to calculate the probability of primary HIV infection and expected secondary HIV infections. The key parameter that changes for each fiscal year are partner prevalence estimates. These estimates are from the 2001 consensus meeting sponsored by the CDHS/OA [5]. The annual increase in incidence among men who have sex with men (MSM) was not reported. We selected an increase of 1.25 percent annually, a conservative estimate compared with the incidences of 2.6 percent [6] and 3.5 percent [7] among MSM populations. Prevalence estimates are provided in Table 5.

Table 4. Model Parameters for Calculating Probability of HIV Infections

Per-act HIV transmission probability	Base	Sensitivity Analysis 1	Sensitivity Analysis 2	Source
Receptive anal intercourse	0.020	0.032	0.008	Pinkerton et al. [8]
Receptive vaginal intercourse	0.001	0.002	0.001	Pinkerton et al. [8]
Insertive anal or vaginal intercourse	0.001	0.001	0.000	Pinkerton et al. [8]
Condom effectiveness	0.900	0.800	1.000	Pinkerton et al. [8]
Average contacts per partner				
MSM				
1 partner	9	11	7	Cohen et al. [4]
2+ partners	1	1	1	-
Heterosexual				
1 partner	13.5	15.5	11.5	Cohen et al. [4]
2+ partners	1	1	1	-

MSM = Men who have sex with men.

Table 5. HIV Prevalence Estimate

Fiscal Year	Base			Sensitivity Analysis 1			Sensitivity Analysis 2		
	MSM	Male	Female	MSM	Male	Female	MSM	Male	Female
2000-2001	0.15000	0.00043	0.00085	0.20000	0.00043	0.00085	0.10000	0.00035	0.00070
2001-2002	0.15188	0.00043	0.00085	0.20250	0.00043	0.00085	0.10125	0.00035	0.00070
2002-2003	0.15377	0.00043	0.00085	0.20503	0.00043	0.00085	0.10252	0.00035	0.00070
2003-2004	0.15570	0.00043	0.00085	0.20759	0.00043	0.00085	0.10380	0.00035	0.00070

MSM = Men who have sex with men. Source: CDHS/OA.

Bernoulli probability models were used to estimate the number of HIV infections that would have been expected without and with the HTPP intervention. The former estimate was calculated using client data from the baseline questionnaire. We assumed, on average, that no behavior change would have occurred in the absence of the HTPP intervention. The latter estimate was calculated using client data from clients' furthest follow-up questionnaire. The difference between the two questionnaires served as an estimate of the number of HIV infections the intervention likely prevented.

HIV infections averted were calculated for three risk groups – MSM, heterosexual males, and heterosexual females – and by client HIV serostatus, for each fiscal year. To estimate HIV infection among HIV-negative males and HIV transmission among HIV-positive males we considered three modes of infection/transmission: heterosexual vaginal intercourse, heterosexual anal intercourse, and homosexual anal intercourse. To estimate infection/transmission among HIV-negative and positive females we considered two modes of infection/transmission – heterosexual anal and vaginal intercourse. We then pooled the three estimates (for positive and negative clients separately) to calculate the average primary and secondary infections averted. A weighted average of the number of infections averted per client was then calculated, to estimate the average measure of program effectiveness. This average was calculated as one minus the product of primary infections averted and the proportion of HIV-positive clients plus the product of secondary infections averted and the proportion of HIV-negative clients [9]. To calculate total HIV infections averted we took the product of this weighted average and total number of clients in the program, for each fiscal year.

Sensitivity Analyses

In an effort to review how a model varies when estimates vary it is recommended that a sensitivity analysis be undertaken [10]. For this study, we performed two multivariate sensitivity analyses. The goal was to develop what can be considered the plausible range of estimated HIV infections prevented by HTPP. In the first sensitivity analysis, we modeled what we expect will produce the minimum number of infections and in the second sensitivity analysis, the maximum number of infections the intervention likely prevented. In developing these type of scenarios, and observing the range of the estimates, the hypothesis is that estimates from the base case scenario are the more likely 'true' number of infections averted – given those estimates represent the midpoint of the two extremes and have more realistic model assumptions. The prevalence inputs utilized in the base case in Table 5, for example, reflect the mid-point of the range reported, whereas, the values utilized in the sensitivity analysis reflect the minimum and maximum values reported.

In the first sensitivity analysis, we increased all model parameters to create a scenario where the probability of infection was theoretically higher. We increased the per-act transmission probability (for all acts), decreased the condom effectiveness rate, and increased the number of contacts per partner (only applies to the client's first partner). In addition, the prevalence among partners was increased. In this scenario medical care cost estimates were held constant.

RESULTS

Sample

A baseline and/or follow-up questionnaire was collected from 581 clients during the four fiscal years. Most HTPP clients were male (71.6 percent). Almost half (46.3 percent) were White and nearly one-third (31.5 percent) were Latino. Two-thirds (66.8 percent) were HIV positive. The gender, race/ethnicity, and serostatus of clients included in the economic analysis are also presented in Table 6.

Program Cost

Total adjusted program cost for the four fiscal years was $3,783,815 (mean = $945,954, range = $850,603 for 2000-2001 to $1,004,679 for 2001-2002) (Table 7). Sixty-six percent of program cost, on average, was directed towards personnel over the four years (Table 8).

Table 9 presents the number of (duplicate) clients receiving services in each fiscal year. A baseline and/or one of the follow-up questionnaires was received from an average of 177 clients per fiscal year (2000-2001 = 116; 2001-2002 = 180;

2002-2003 = 225; 2003-2004 = 186). The average cost per year in Table 9 is equal to the total program cost (Table 7) over total clients receiving services in each fiscal year. The average cost per HTPP client was slightly higher for persons living with HIV, and overall was $5,597.

Table 6. Client Demographics

	Total Clients (n=581), %	Clients Included in the Economic Evaluation (n=194), %
Gender		
Male	71.6	73.2
Female	24.6	26.8
Transgender	0.9	-
Missing	2.9	-
Race/Ethnicity		
White	46.3	44.8
Latino	31.5	37.1
African American	12.6	12.4
Other	6.7	5.7
Missing	2.9	-
HIV Serostatus		
Positive	66.8	70.6
Negative	29.6	29.4
Missing	3.6	-

Source: CDHS/OA.

Table 7. Total Program Cost by Fiscal Year and HIV Serostatus of Client

Fiscal Year	Program Cost	HIV-Positive Clients	HIV-Negative Clients
2000-2001	$ 850,603.40	$ 579,007.11	$ 271,596.29
2001-2002	$ 1,004,679.48	$ 737,168.33	$ 267,511.15
2002-2003	$ 958,680.41	$ 638,424.32	$ 320,256.09
2003-2004	$ 969,851.72	$ 638,580.71	$ 331,271.01
Average	$ 945,953.75	$ 648,295.12	$ 297,658.63
Total	$ 3,783,815.01	$ 2,593,180.48	$ 1,190,634.53

Source: CDHS/OA.

Table 8. Program Costs by Category as Percent of Total Program Cost by Fiscal Year

Category	Average	2000	2001	2002	2003
Personnel	66%	66%	63%	66%	67%
Other	19%	14%	22%	19%	22%
Operating	10%	14%	9%	12%	5%
Indirect	4%	5%	4%	3%	4%
Capital	1%	1%	1%	0%	2%

Source: CDHS/OA.

Table 9. Number of Clients Overall During Each Fiscal Year and Average Cost per Client by HIV Serostatus of Client

Fiscal Year	Number of Clients Overall			Cost per Client		
	HIV Positive	HIV Negative	Total	HIV-Positive Clients	HIV-Negative Clients	Total
2000-2001	68	48	116	$ 8,514.81	$ 5,658.26	$ 7,332.79
2001-2002	118	62	180	$ 6,247.19	$ 4,314.70	$ 5,581.55
2002-2003	156	68	225	$ 4,092.46	$ 4,709.65	$ 4,260.80
2003-2004	134	49	186	$ 4,765.53	$ 6,760.63	$ 5,214.26
Unweighted Average	119	57	177	$ 5905.00	$ 5360.81	$ 5597.35

Source: CDHS/OA.

Note: Unduplicated clients overall, n = 518. For fiscal years 2002-2003 and 2003-2004, one and three clients were coded as HIV-serostatus unknown, respectively.

In Table 10 is the distribution of the number of clients included in the cost-effective analysis over the four fiscal years. The estimated program cost for HIV-positive and HIV-negative clients, for each fiscal year, is derived by taking the product of the average cost per client (from Table 9) and clients receiving services from Table 10. The overall estimated program cost for each fiscal year and overall represents the sum of the estimated program cost for HIV-positive and HIV-negative clients.

Table 10. Number of Clients Included in Cost-Effective Analysis during Each Fiscal Year and Estimated Program Cost by HIV Serostatus of Client

Fiscal Year	Number of Clients in Economic Analysis			Estimated Program Cost		
	HIV Positive	HIV Negative	Total	HIV-Positive Clients	HIV-Negative Clients	Total
2000-2001	25	15	40	$ 212,870.25	$ 84,873.90	$ 297,744.15
2001-2002	64	34	98	$ 399,820.16	$ 146,699.80	$ 546,519.96
2002-2003	93	35	128	$ 380,598.78	$ 164,837.75	$ 545,436.56
2003-2004	76	28	104	$ 362,180.28	$ 189,297.64	$ 551,477.92
Unweighted Average	65	28	93	$ 338,867.35	$ 146,427.28	$ 485,294.65
Total	-	-	-	$ 1,355,469.47	$ 585,709.12	$ 1,941,178.59

Note: Unduplicated clients in Cost-Effective Analysis, n = 194. Source: CDHS/OA.

Estimated HIV Infections Averted

In Table 11 presents the average probability of infection (for HIV-negative clients) and total secondary HIV infections averted (HIV-positive clients), and the estimate of the average number of infections averted per client, for each fiscal year. The number of HIV infections averted per year is the product of the average number of infections averted per client and the number of individual clients completing a baseline in each year.

The results suggest that it was not until fiscal year 2002-2003, when the average infections averted per client was .1163, that the intervention had a major impact on preventing HIV infections. During this year a total of seven HIV infections were averted. In 2003-2004, the intervention has a positive effect on both HIV-negative and positive clients. The average number of infections averted per client climbed to .4071, and although this year has the fewest number of clients (n=28), 11 HIV infections were estimated to have been averted.

Table 11. Estimated HIV Infections Averted, Base Case Analysis, by Fiscal Year

	Fiscal Year			
	2000-2001	2001-2002	2002-2003	2003-2004
Average probability of infection	0.0515	0.0235	-	0.0007
Total secondary HIV infections averted	-	-	0.1527	0.5697
Average infections averted per client	0.0191	0.0072	0.1163	0.4071
Number of clients	35	68	63	28
HIV infections averted, rounded (actual)	1 (0.6685)	0 (0.4896)	7 (7.3269)	11 (11.3988)

Note: Negative values were excluded. Source: CDHS/OA.

Further analyses revealed that in fiscal years 2000-2001 and 2001-2002, HIV-negative clients decreased their risk behavior, post-baseline, enough to produce a positive estimate (indicating a decrease in the average probability of infection). In the same timeframe, and on average, this was not the case for HIV-positive clients. A review of the results by each risk group suggested MSM and heterosexual males had more risky behavior post-baseline, while HIV-positive females did not. In 2001-2002, only HIV-positive heterosexual males did not decrease their risk behavior, post baseline. In 2002-2003, we saw the opposite pattern, HIV-positive clients decreased in the average number of primary HIV infections expected to occur, but HIV-negative clients do not decrease their probability of infection, on average. In this case, HIV-negative MSM did not decrease their probability of infection.

Cost-effective Ratio

Table 12 presents by fiscal year the projected number of HIV infection averted (from Table 11), HTPP program cost estimates (from Table 10), and the discounted lifetime cost of treating a case of HIV/AIDS (the adjusted intermediate base case figure from Table 3). These data are required to calculate cost-effective ratios, cost-saving thresholds, and to conclude whether HTPP was a cost-effective or a cost-saving intervention.

The cost-effective ratio is equal to program costs over HIV infections averted, or the average cost to avert each HIV infection [10]. The cost-effective ratio for 2000-2001 is \$297,744 over 0.6685, or \$445,391. Prevention programs that cost less than \$750,000 per HIV infection averted are considered cost-effective [10]. The inflation adjusted cost is \$782,940. In Table 12 we see that HTPP was cost-effective in each year of operation, except in 2001-2002 (\$1,116,258 > \$782,940), which is the same year the least number of HIV infections were averted (0.4896). The cost-saving threshold represents the product of the number of HIV infections averted and the program cost estimate. The cost saving figure is the difference of the cost-saving threshold and the program cost estimate. In Table 12 we see that in the last two years of program operation the intervention became cost-saving.

Table 12. Cost-effective Ratio, Base Case Analysis, by Fiscal Year

	2000-2001	2001-2002	2002-2003	2003-2004
HIV infections averted	0.6685	0.4896	7.3269	11.3988
Program cost estimate	$ 297,744	$546,520	$545,437	$551,478
Discounted lifetime cost of treating a case of HIV/AIDS	$255,849	$255,849	$255,849	$255,849
Cost-effective ratio	$445,391	$1,116,258	$74,443	$48,380
Cost-saving threshold	$171,035	$125,263	$1,874,579	$2,916,370
Cost-saving	($126,709)	($421,257)	$1,329,142	$2,364,892

Source: CDHS/OA.

Sensitivity Analyses

Results for the first of two sensitivity analyses is presented in Table 13. In relative terms, only in fiscal year 2001-2002 did estimates change – the model suggests that one HIV infection was prevented. In general, we observed that in most years, relative to the base case scenario, the average probability of infection increased modestly and total secondary HIV infections averted decreased modestly, as expected. In terms of the cost-effective ratio, we would expect the cost-effectiveness of the intervention to remain, in general, unchanged given the number of HIV infections averted was fairly similar to the base case scenario, and this indeed turns out to be the case (Table 14).

Table 13. HIV Infections Averted, Sensitivity Analysis 1, by Fiscal Year

	Fiscal Year			
	2000-2001	2001-2002	2002-2003	2003-2004
Average probability of infection	0.0513	0.0310	-	0.0009
Total secondary HIV infections averted	-	-	0.1468	0.5362
Average infections averted per client	0.0191	0.0096	0.1118	0.3833
Number of clients	35	68	63	28
HIV infections averted, rounded (actual)	1 (0.6685)	1 (0.6528)	7 (7.0434)	11 (10.7324)

Note: Negative values were excluded. Source: CDHS/OA.

In fiscal year 2001-2002, the program inched towards being more cost-effective, although that goal was still not achieved. In the worst case scenario, the program is capable of remaining cost-effective three of four years in operation and cost-saving in the final two years of operation.

Table 14. Cost-effective Ratio, Sensitivity Analysis 1, by Fiscal Year

	2000-2001	2001-2002	2002-2003	2003-2004
HIV infections averted	0.6685	0.6528	7.0434	10.7324
Program cost estimate	$297,744	$546,520	$545,437	$551,478
Discounted lifetime cost of treating a case of HIV/AIDS	$255,849	$255,849	$255,849	$255,849
Cost-effective ratio	$445,391	$837,194	$ 77,439	$51,384
Cost-saving threshold	$170,035	$167,018	$1,802,047	$2,745,874
Cost-saving	($126,709)	($379,502)	$1,256,610	$2,194,396

Source: CDHS/OA.

In the second sensitivity analysis, we flipped the parameters to be more conservative than the base case scenario – we assumed lower per-act probabilities for HIV transmission, lower prevalence among HIV partners, no condom failure, and a decreased number of contacts per partner. In this scenario (Table 15), medical care cost estimates were again held constant. Relative to the base case scenario, HIV-negative clients had a lower probability of infection and more HIV infections were averted among HIV-positive clients. This has the effect of increasing the number of HIV infections averted in the last two fiscal years, with a net gain of two infections prevented.

Table 15. HIV Infections Averted, Sensitivity Analysis 2, by Fiscal Year

	Fiscal Year			
	2000-2001	2001-2002	2002-2003	2003-2004
Average probability of infection	0.0486	0.0161	-	0.0006
Total secondary HIV infections averted	-	-	0.1593	0.5993
Average infections averted per client	0.0180	0.0050	0.1214	0.4282
Number of clients	35	68	63	28
HIV infections averted, rounded (actual)	1 (0.6300)	0 (0.3400)	8 (7.6482)	12 (11.9896)

Note: Negative values were excluded. Source: CDHS/OA.

In Table 16 we see the expected changes across the cost-effective metrics. In the years where an increase was found for number of HIV infections prevented, we see a corresponding increase in total cost-savings. In addition, we see a similar trend as in the other scenarios: the program was cost-effective three of four years in operation.

Table 16. Cost-effective Ratio, Sensitivity Analysis 2, by Fiscal Year

	2000-2001	2001-2002	2002-2003	2003-2004
HIV infections averted	0.6300	0.3400	7.6482	11.9896
Program cost estimate	$297,744	$546,520	$545,437	$551,478
Discounted lifetime cost of treating a case of HIV/AIDS	$255,849	$255,849	$255,849	$255,849
Cost-effective ratio	$472,610	$1,607,412	$71,316	$45,996
Cost-saving threshold	$161,185	$86,989	$1,956,784	$3,067,527
Cost-saving	($136,559)	($459,531)	$1,411,347	$2,516,049

Source: CDHS/OA.

DISCUSSION

The intent of the current study was to utilize four fiscal years of self-reported behavioral and economic data to assess trends from a state-wide prevention case management intervention, and to use these data as inputs into a probability model to determine the annual number of HIV infections prevented. In terms of program outcomes, the increasing number of HIV infections averted per year suggests that over time the program became more effective at influencing client behavior, this trend was observed in a sensitivity analysis as well. In terms of economic trends and when excluding fiscal year 2001-2002, we observed a decline in the cost-effective ratio and an increase in cost-savings. These findings offer promise for this and plausibly similar prevention interventions that target high-risk populations while consuming a substantial amount of resources. These results provide the primary answer to the basic question of the current analysis, to determine if the efforts of the prevention intervention were 'worth it' relative to the observed outcomes.

To be conservative, researchers, policy makers, and prevention program decision-makers should consider the amount of uncertainty built into probability models that attempt to estimate the number of HIV infections prevented, especially when considering populations that have an HIV prevalence greater than .10 [8]. In reality, intervention impact is better modeled for populations with low to moderate HIV risk and more caution should be applied when considering more risky populations [8]. To some degree, uncertainty is decreased in the following study given the longitudinal data, however, uncertainty is never completely eliminated. The key areas that make results uncertain include the lack of data indicating frequency of sex acts for each client partner and precision of estimates of prevalence for each fiscal year. The economic data and cost analysis also carry some level of uncertainty with regard to estimates involving lifetime medical care costs and program cost estimates; however, these estimates are quite sound and stand alongside other published data and require fairly straightforward methods to derive each estimate.

In nearly all areas where inputs require estimation, the use of standardized metrics was employed. This practice is encouraged in the literature, and tends to increase model stability, given the lack of uncertainty for any given metric. The same method is applied when considering frequency of sexual acts. Obviously, risk and transmission of HIV infection depend in part on frequency of sexual acts. Therefore, the average frequency of sexual acts is an important estimate when attempting to model new HIV infections. Unfortunately, this metric is often not collected in behavioral surveys [8]. Given this reality, the alternate is to use data from published estimates. A national survey by Laumann, et al. [11] found average frequency of sex acts tends to be stable among different population subgroups. However, the degree to which these assumptions hold for more risky populations and with clients who have multiple partners is unknown. To prevent a substantial overestimation of sexual contact, this study used a conservative estimate for clients with greater than one partner. The estimate is likely unrealistic but may average out when considering clients with only one additional partner verses a client with a very high number of partners. Additional data in this area would assist with increasing the stability of the probability model. HIV prevalence by subgroup also involves some degree of uncertainty, but to a lesser degree.

The prevalence estimates we leveraged from a consensus meeting organized and facilitated by CDHS/OA, HIV/AIDS Epidemiology Branch [5]. The use of these metrics which are assumed to be standard and best estimates provide value to the probability model and ensure greater accuracy; however, the area of concern involve the rate of change of prevalence over time. The study assumed a conservative rate, since none was provided for MSM. The degree to which the model underestimated the change in prevalence is the degree the model underperformed in accuracy. While prevalence was assessed in the sensitivity models the rate of change over years was constant. In addition, the rate of change was fairly conservative, which is almost assuming an unchanged and stable estimate of prevalence. Theoretically, there are an unlimited number of sensitivity analyses that can be carried out to assess how each estimate and a change thereof may change the program outcomes, but in reality it is common practice to perform a few focused follow-ups to determine the degree which variation influences the base case model. In this study, no drastic changes were observed.

HTPP was driven by a need to focus prevention resources on persons already infected with HIV. There is real value in reviewing the trends found from this study; however, caution should also be exercised when attempting to generalize these results to future prevention programs. We assume program officials would want to extrapolate results to a future prevention project; however, several considerations would be necessary prior to assuming any project could have a similar impact as HTPP. At the client level, it would be important to consider the populations' prevalence and the level of behavioral risk and general behavior patterns. At the program level, the level of expertise of the staff would also be important. The changes in these areas would have a respective change in outcomes. Stated in simple terms, a large use of resources would not make sense in a prevention project that desired similar outcomes but focused on a population with a lower prevalence and had a much lower level of risk of infection. In this (exaggerated) scenario, we would, of course, expect to see a quite ineffective project with high costs and low infections prevented, if any. It is worthwhile to constantly consider the context which our results were derived.

In summary, HTPP was capable of becoming a project that was cost-saving while demonstrating effectiveness in preventing HIV infection among both HIV-negative and preventing transmission among HIV-positive clients. The efforts of documenting both programmatic activities, in terms of accounting for programmatic expenditures, and collecting client-level behavioral data paid dividends in terms of offering a sufficient amount of data to review long term program accomplishments. Additionally, the project can use results, herein, to support the claim that expensive investments in HIV prevention resources may well be worth the upfront cost, considering the trade off in future medical care costs.

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